

**WE CLAIM:**

- 1           1.       A photodiode array, comprising:  
2           a plurality of arrayed individual diode devices, including:  
3                   at least one active photodiode; and  
4                   at least one reference diode.
  
- 1           2.       The photodiode array of claim 1 wherein the diode devices are  
2       fabricated on a single semiconductor substrate.
  
- 1           3.       The photodiode array of claim 2 wherein the photodiode array  
2       includes a substrate and each of the diode devices includes:  
3                   a first layer of substantially intrinsic semiconductor material of a first  
4       conductivity type;  
5                   a second layer of a doped semiconductor material of the first conductivity  
6       type located at one of in and over the first layer;  
7                   a third layer of semiconductor material of a second conductivity type located  
8       at one of in and over the second layer.

1           4.       The photodiode array of claim 3 wherein each diode device further  
2 includes:

3           a region of a doped semiconductor material of the second conductivity type  
4 that is one of:

5                     sandwiched as a layer between the substrate and the first layer; and

6                     in contact with the first layer; and

7           the region having a higher carrier concentration than the first layer.

1           5.       The photodiode array of claim 2 further comprising a biasing circuit  
2 that:

3           applies a first bias voltage to each of the at least one reference diode;

4           applies a second bias voltage to each of the at least one active photodiode,

5 the second bias voltage having a predetermined relationship with the first bias

6 voltage;

7           monitors operation of the at least one reference diode at the applied first bias

8 voltage; and

9           adjusts the applied first bias voltage to drive the monitored operation of the

10 at least one reference diode to an optimal condition.

1           6.       The photodiode array of claim 5 wherein the predetermined

2 relationship between the first and second bias voltages is equality.

1           7.       The photodiode array of claim 5 wherein the biasing circuit  
2     comprises:  
3           a bias voltage generator having outputs connected to apply the first bias  
4     voltage to the at least one reference diode and the second bias voltage to the at least  
5     one active photodiode;  
6           a detector having an input connected to the at least one reference diode to  
7     measure an operational characteristic thereof in response to the first bias voltage;  
8     and  
9           a comparator that compares the measured certain operational characteristic to  
10    a reference value and controls the bias voltage generator to adjust the first and  
11    second bias voltages in a manner that drives the measured certain operational  
12    characteristic to substantially match the reference value.

1           8.       The photodiode array as in claim 7 wherein the operational  
2     characteristic comprises a reference diode responsivity at the applied first bias  
3     voltage.

1           9.       The photodiode array as in claim 8 wherein the reference diode  
2     responsivity is measured for a known intensity of light incident on the at least one  
3     reference diode.

1           10.     The photodiode array as in claim 9 wherein the reference diode  
2     responsivity is measured in the absence of incident light on the at least one reference  
3     diode.

1           11.     The photodiode array as in claim 6 wherein:  
2             the at least one reference diode provides an output current; and  
3             the detector measures the output current of the at least one reference  
4     photodiode at the applied first bias voltage.

1           12.     The photodiode array as in claim 11 wherein the detector measures  
2     the output current at one of (a) a known intensity and (b) zero intensity of light  
3     incident on the at least one reference diode.

1           13.     The photodiode array as in claim 11 wherein the reference diode  
2     includes:  
3             a high field region; and  
4             means for injecting charge carriers to be swept into the high field region to  
5     generate the reference diode output current.

1           14.    The photodiode array as in claim 13 wherein:  
2           the biasing circuit comprises a current generator for applying a  
3   predetermined input current to the means for injecting charge carriers;  
4           the detector operates to determine a relationship between the reference diode  
5   output current and the input current and thereby obtain a value indicative of  
6   responsivity of the at least one reference diode;  
7           the reference value comprises a reference responsivity; and  
8           the comparator operates to compare the value indicative of responsivity to  
9   the reference responsivity.

1           15.    The photodiode array as in claim 11 wherein the detector determines  
2   a derivative of the logarithm of the output current, and wherein the comparator  
3   compares the obtained derivative of the logarithm of the output current to a  
4   reference.

1           16.    The photodiode array of claim 5 wherein the biasing circuit is  
2   additionally fabricated in the single semiconductor substrate.

1           17.     A biasing circuit for an avalanche photodiode having at least one  
2     associated reference diode, the biasing circuit comprising:  
3           a bias voltage generator having a first output for applying a first bias voltage  
4     to the at least one reference diode and a second output for applying a second bias  
5     voltage to the avalanche photodiode, the second bias voltage having a predetermined  
6     relationship with the first bias voltage;  
7           a detector having an input connected to the at least one reference diode to  
8     measure an operational characteristic thereof in response to the first bias voltage;  
9     and  
10          a comparator that compares the measured operational characteristic to a  
11     reference value and that controls the bias voltage generator to adjust the first bias  
12     voltage and the second bias voltage in a manner that drives the measured operational  
13     characteristic to substantially match the reference value.

1           18.     The biasing circuit as in claim 17 wherein the predetermined  
2     relationship between the first bias voltage and the second bias voltage is equality.

1           19.     The biasing circuit as in claim 17 wherein the operational  
2     characteristic comprises a reference diode responsivity at the applied first bias  
3     voltage.

1           20.     The biasing circuit as in claim 19 wherein the reference diode  
2     responsivity is measured for a known intensity of light incident on the at least one  
3     reference diode.

1           21.     The biasing circuit as in claim 20 wherein the reference diode  
2     responsivity is measured in the absence of incident light on the at least one reference  
3     diode.

1           22.     The biasing circuit as in claim 17 wherein:  
2             the at least one reference diode provides an output current; and  
3             the detector measures the output current of the at least one reference  
4     photodiode at the applied first bias voltage.

1           23.     The biasing circuit as in claim 22 wherein the detector measures the  
2     output current at one of (a) a known intensity and (b) zero intensity of light incident  
3     on the at least one reference diode.

1           24.     The biasing circuit as in claim 22 wherein the reference diode  
2     includes:  
3             a high field region; and  
4             means for injecting charge carriers to be swept into the high field region to  
5     generate the reference diode output current.

1           25.     The biasing circuit as in claim 24 further including:  
2           a current generator for applying a predetermined input current to the means  
3     for injecting charge carriers;  
4           and wherein:  
5           the detector operates to determine a relationship between the reference diode  
6     output current and the input current and thereby obtain a value indicative of  
7     responsivity of the at least one reference diode;  
8           the reference value comprises a reference responsivity; and  
9           the comparator operates to compare the value indicative of responsivity to  
10    the reference responsivity.

1           26.     The biasing circuit as in claim 22 wherein the detector determines a  
2     derivative of the logarithm of the output current, and wherein the comparator  
3     compares the obtained derivative of the logarithm of the output current to a  
4     reference.

1           27.     The biasing circuit of claim 17 wherein the biasing circuit, reference  
2     diode and avalanche photodiode are fabricated in the same semiconductor substrate.

1           28.     An avalanche photodiode, comprising:  
2           a high field area associated with a pn junction; and  
3           means for injecting charge carriers to be swept into the high field region to  
4     generate diode output current.

1           29.     The avalanche photodiode as in claim 28:  
2           wherein the pn junction is formed from a first conductivity type layer and a  
3     second conductivity type layer formed at one of in and over the first conductivity  
4     type layer; and  
5           wherein the means for injecting comprises a heavily doped second  
6     conductivity type region physically separate from the layers forming the pn junction  
7     and comprising a source of the charge carriers that are swept into the high field area.

1           30.     The avalanche photodiode as in claim 29 further including an  
2     electrode connected to the heavily doped second conductivity type region, the  
3     electrode receiving an input current in response to which the charge carriers are  
4     injected into the high field area.

1           31.     The avalanche photodiode as in claim 29 further including a  
2     substantially intrinsic layer of the first conductivity type physically separating the  
3     heavily doped second conductivity type region from the first conductivity type layer  
4     of the pn junction.

1           32.     The avalanche photodiode as in claim 31 further including an  
2     additional first conductivity type region separating the heavily doped second  
3     conductivity type region from the substantially intrinsic layer.

1           33.     The avalanche photodiode as in claim 31 further including a substrate  
2     layer underlying the heavily doped second conductivity region.

1           34.     The avalanche photodiode as in claim 33 further including a pair of  
2     electrodes, one electrode of the pair connecting to a layer of the pn junction and  
3     another electrode of the pair connecting to the substrate layer, wherein a reverse bias  
4     voltage is applied between the pair of electrodes to generate the high field area.

1           35.     A method for biasing an avalanche photodiode having an associated  
2     reference diode, comprising the steps of:  
3           generating a first bias voltage for application to the reference diode;  
4           generating a second bias voltage for application to the avalanche photodiode,  
5     the second bias voltage having a predetermined relationship with the first bias  
6     voltage;  
7           measuring an operational characteristic of the reference diode in response to  
8     application of the first bias voltage;  
9           comparing the measured operational characteristic to a reference value; and  
10          adjusting the first bias voltage and second bias voltage in a manner that  
11     drives the measured operational characteristic to substantially match the reference  
12     value.

1           36.     The method as in claim 34 wherein the predetermined relationship  
2     between the first and second bias voltages is equality.

1           37.     The method as in claim 35 wherein the operational characteristic  
2     comprises a reference diode responsivity at the applied first bias voltage.

1           38.     The method as in claim 35 further including the step of applying a  
2     known intensity of light incident on the reference diode, and wherein the step of  
3     measuring the reference diode responsivity is measured for that known intensity of  
4     light.

1           39.     The method as in claim 37 wherein the reference diode responsivity  
2     is measured in the absence of incident light on the at least one reference photodiode.

1           40.     The method as in claim 35 further including the step of generating an  
2     output current from the reference diode and wherein the step of measuring  
3     comprises the step measuring the output current at the applied first bias voltage.

1           41.     The method as in claim 40 wherein the output current is measured at  
2     one of (a) a known intensity and (b) zero intensity of light incident on the reference  
3     diode.

1           42.     The method as in claim 40 further comprising the steps of:  
2           applying a predetermined input current to the matched reference diode;  
3           injecting charge carriers proportional to the predetermined input current to  
4     be swept into a high field region of the reference diode to generate the diode output  
5     current; and  
6           determining a relationship between the output current and the input current  
7     to obtain a value indicative of the responsivity of the reference diode;  
8           wherein the reference value comprises a reference responsivity, and  
9           wherein the step of comparing compares the obtained value indicative of the  
10    responsivity to the reference responsivity.

1           43.     The method as in claim 40 further including the step of:  
2           determining a derivative of the logarithm of the output current, and wherein  
3     the step of comparing compares the obtained derivative of the logarithm of the  
4     output current to a reference.